# Extension of 3D Geological Solid Modeling Method to 3D DDA (Postprint)

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## Abstract

The Discontinuous Deformation Analysis (DDA) method has been widely recognized for simulating rock behaviors such as rolling, collision, toppling, and sliding, as its simulation results show high consistency with experimental and field observations. Moreover, with the development of 3D DDA technology in areas such as precise stress field analysis and fracture propagation simulation, this method demonstrates significant advantages in solving continuous-discontinuous coupling problems. However, current 3D DDA modeling research primarily focuses on rock mass joint fracture network construction and three-dimensional cutting algorithm development, while its supporting three-dimensional geological modeling methods still exhibit obvious deficiencies, particularly a bottleneck of excessive time consumption in modeling efficiency. Furthermore, the lack of pre-processing modeling tools and visual operation interfaces severely restricts the engineering application and promotion of 3D DDA technology. Therefore, this study integrates interdisciplinary technologies including UAV oblique photography, three-dimensional reconstruction, intelligent cutting algorithms, computer graphics, and visualization program design to innovatively construct a three-dimensional geological body modeling methodology system oriented toward 3D DDA, and develops a supporting program system based on C++ graphics libraries and C language interfaces. The core technical pathway of this method includes: first, employing NURBS surfaces to accurately construct three-dimensional solid model boundaries containing geological elements such as strata and faults, establishing an initial numerical model through finite element mesh generation; subsequently, utilizing topological conversion technology to transform the finite element mesh into a block system model that meets 3D DDA computational requirements. To meet the demands of different engineering scenarios, the system supports sub-block integrated modeling and arbitrary polyhedral model construction. Through modeling practice validation on typical geological structure cases, this method demonstrates significant advantages in efficiency and accuracy, successfully achieving efficient construction of high-

precision three-dimensional geological models. Meanwhile, the core technologies developed in this study, such as the multi-layer NURBS modeling method and topological conversion mechanism, possess universal value and can be extended to modeling workflows of other numerical simulation methods, providing new research directions for technological development in the field of computational rock mechanics.

## Full Text

## Extension of a 3D Geological Entity Modeling Method in 3D DDA

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## Abstract

The Discontinuous Deformation Analysis (DDA) method has gained widespread recognition for simulating rock mass behaviors such as rolling, collision, toppling, and sliding, as its simulation results demonstrate high consistency with experimental and field observations. With the advancement of 3D DDA technology in areas including precise stress field analysis and fracture propagation simulation, this method has shown remarkable advantages in solving continuous-discontinuous coupling problems. However, current research on 3D DDA modeling primarily focuses on the construction of rock mass joint networks and the development of three-dimensional cutting algorithms, while the supporting three-dimensional geological modeling methods remain notably inadequate. In particular, modeling efficiency poses a significant bottleneck due to excessive time consumption. Furthermore, the absence of pre-processing modeling tools and visualization interfaces severely constrains the broader engineering application and promotion of 3D DDA technology.

To address these challenges, this study innovatively establishes a comprehensive three-dimensional geological modeling methodology for 3D DDA by integrating interdisciplinary technologies including UAV oblique photogrammetry, three-dimensional reconstruction, intelligent cutting algorithms, computer graphics, and visualization programming. A supporting program system has been developed based on C++ graphics libraries and C language interfaces. The core technical pathway of this method comprises: first, employing NURBS surfaces to accurately construct three-dimensional entity model boundaries that incorporate geological features such as strata and faults, thereby establishing an initial numerical model through finite element mesh generation; subsequently, utilizing topological transformation techniques to convert the finite element mesh into a block system model that satisfies 3D DDA computational requirements. To accommodate diverse engineering scenarios, the system supports both sub-block integrated modeling and arbitrary polyhedron model construction.

Validation through modeling practices on typical geological structure cases demonstrates that the proposed method exhibits significant efficiency advantages while ensuring accuracy, successfully achieving high-efficiency construction of high-precision three-dimensional geological models. Meanwhile, the core technologies developed in this study, including the multi-layer NURBS modeling method and topological transformation mechanism, possess universal applicability and can be extended to modeling workflows for other numerical simulation methods, thereby providing new research directions for technological development in the field of computational rock mechanics.

**Keywords**: 3D DDA; continuous-discontinuous; three-dimensional geological modeling; three-dimensional cutting; NURBS